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L12	345/629	1930	L12
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L7	707/1	9306	L7
L6	345.clas.	83685	L6
L5	707.clas.	42230	L5
L4	L3 and (3d or "three dimensional" or "three dimension")	155	L4
L3	L2 and objects near (data with base or database)	232	L3
L2	L1 and (manipulat$ near2 data or manipulat$ with data or manipulat$ adj data)	3683	L2
L1	("computer aided design" or "cad")	60521	L1

END OF SEARCH HISTORY

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L4: Entry 102 of 155   File: USPT   Jul 16, 2002

DOCUMENT-IDENTIFIER: US 6420698 B1
TITLE: Integrated system for quickly and accurately imaging and modeling three-dimensional objects

Abstract Text (1):
An integrated system generates a model of a three-dimensional object. A scanning laser device scans the three-dimensional object and generates a point cloud. The points of the point cloud each indicate a location of a corresponding point on a surface of the object. A first model is generated, responsive to the point cloud, that generates a first model representing constituent geometric shapes of the object. A data file is generated, responsive to the first model, that can be inputted to a computer-aided design system.

Brief Summary Text (2):
The present invention relates generally to systems that document the geometry and other attributes of objects in three dimensions and, specifically, to a system that employs a scanning lidar (range finding laser) to quickly and accurately sense the position in three-dimensional space of selected points on the surface of an object to generate a point cloud which represents the sensed positions of the selected points; that recognizes geometric shapes represented by groups of points in the point cloud, and that generates a model that represents these geometric shapes. The model may be transformed into a further model usable by computer-aided design (CAD) tools, including conventional CAD tools.

Brief Summary Text (4):
Mapping the geometry (shape, dimensions and location) and other attributes (e.g., color, texture and reflectance intensity) of complex real objects (whether small components such as small mechanical parts or large objects such as buildings and sites) has conventionally been a tedious and time consuming process. That is, such measurement have traditionally been performed manually. In addition, transforming these measurements into drawings or computer models required manual drafting or input into a CAD system for the production of the drawing or computer models.

Brief Summary Text (5):
Recently innovations have endeavored to simplify this process, but all have fallen short of achieving full integration, automation, precision, speed and range. For example, in the building industry, mapping a structure conventionally requires three basic steps: 1. Field data gathering 2. Data reduction and preparation 3. Drafting and CAD The field data gathering step is performed by a team of surveyors who manually measure and record dimensions of pertinent components of the structure such as walls, ceilings, beams, columns, doors, windows, fixtures, pipes, conduits and equipment. The surveyors attempt to determine the geometry of the components as well as the relative location of the components in the structure. The surveyors recorded the data in a field notebook. The field-collected data is then organized and reduced to tables and organized sketches, and a CAD operator or drafter utilizes these tables to generate final drawings or models.

Brief Summary Text (7):
Recently, the field step has been somewhat automated by using a laser ranging device built into or mounted on an electronic theodolite. Precision reflection

targets (retro reflectors) are placed at the locations of the object for which measurements are desired. Then, the laser ranging device obtains a precise measurement of the distance between the instrument and the target, which the theodolite provides an accurate indication of the horizontal and vertical angle offsets to the point relative to a given coordinate system. The distance and angle data are either recorded automatically on a magnetic device connected to the instrument or are reduced within the instrument to Cartesian coordinates relative to the instrument axes. This procedure is then repeated as many times as necessary to map a desired number of points of the object. The collected coordinates data can then be plotted directly on a CAD system.

Brief Summary Text (9):
Another known field gathering data process employs stereo photography and aerial photogrammetry. That is, stereoscopic images are taken of the objects and the resulting stereo photographs are registered either manually or using computerized techniques to reproduce the relative location of the camera picture plane location at the time each photograph was taken. The data reduction and preparation step is performed manually by a specially trained operator. Specifically, with the aid of specially mounted stereoscopic viewing lenses, the operator digitizes the coordinates of a sufficient number of points to allow the definition of the objects using the stereo photographs. Again, the digitized data is input into a CAD system or is manually drawn on paper.

Brief Summary Text (11):
The present invention is an integrated system for generating a model of a three-dimensional object. A scanning laser device-scans the three-dimensional object and generates a point cloud. The points of the point cloud each indicate a location of a corresponding point on a surface of the object. A first model is generated, responsive to the point cloud, representing constituent geometric shapes of the object. A data file is generated, responsive to the first model, that can be inputted to a computer-aided design system.

Brief Summary Text (13):
The present invention further includes a method of manually separating from a plurality of clouds of points, representing three-dimensional features in a scene, a subset of the points that represents a desired feature in the scene, the method comprising: selecting all the point clouds that include at least some data points representing the desired feature; and changing a view of the clouds and drawing a polygonal lasso to refine a selected subset of points to be included in a point sub-cloud and repeating the refining as many times as required to obtain the desired sub-cloud.

Brief Summary Text (17):
The subject invention further includes a method for modeling a three-dimensional scene, comprising: generating a plurality of points that each represent a point on a surface of the scene; determining a best fit of a cylinder for a group of the points using surface normal estimates and global error minimization.

Brief Summary Text (18):
The subject invention further includes a method for modeling a three-dimensional scene, comprising: generating a plurality of points that each represent a point on a surface of the scene; determining a best fit of a cylinder for a group of the points using a quadratic surface fit and global error minimization.

Brief Summary Text (19):
The subject invention further includes a method for modeling a three-dimensional scene, comprising: generating a plurality of points that each represent a point on a surface of the scene; determining a best fit of a sphere for a group of the points using a quadric surface fit and global error minimization.

Brief Summary Text (20):
The subject invention further includes a method for modeling a three-dimensional
scene, comprising: generating a plurality of points that each represent a point on
a surface of the scene; determining a best fit quadric surface for a group of
points; and determining which geometric primitive of a plurality of the family
described by the quadric surface best fits the group of points.

Brief Summary Text (24):
The subject invention further includes an integrated system for generating a model
of a three-dimensional scene, comprising: a scanning laser device that scans the
three dimensional scene with pulsed laser beam wherein the pulses of light last
less than 1 nanosecond with up to 0.2 .mu.J in each pulse and measures the time
delay, with a resolution of 30 psec or less, between each emitted pulse and a
corresponding pulse that is returned from a surface of the scene and wherein said
scanning laser device further tracks and measures the angular orientation of the
beam during the scan; and means for generating a point cloud based upon the
measured time delays and angle measurements, the point cloud comprising a plurality
of data points that each represents a location of a corresponding point on the
surface.

Brief Summary Text (29):
The subject invention further includes an apparatus for obtaining position
information about surface points of a three dimensional object comprising: a laser
for generating an output beam; scanning system for moving the laser beam over the
object; monitoring system for automatically measuring the range to the object based
on the measurement of the reflection of the laser beam, said monitor system also
tracking and measuring the angular position of the laser beam, said monitoring
system having a positional accuracy for each point in three dimensional space equal
to or better than six millimeters at one standard deviation over a range of up to
100 meters.

Brief Summary Text (32):
The subject invention further includes an apparatus for acquiring three dimensional
information from a remote object comprising: a scanning laser module for measuring
position information of the object; a video module for capturing image information
from the object; and a processor for rendering a model of the object which includes
the position information and the image information.

Brief Summary Text (34):
The subject invention further includes an apparatus for obtaining positional
information about surface points of a three dimensional object comprising: a
scanning module for measuring three dimensional position information about an
object; a video module for capturing and displaying image information from the
object; and a processor operating with the scanning and video modules and
permitting the use of the image information captured by said video module to aid in
targeting the scanning module. The processor can function to specify a portion of
the object to be targeted by the scanning module by dragging the image of an
outline over the video image of the area to be targeted.

Brief Summary Text (35):
The subject invention further includes an apparatus for obtaining positional
information about surface points of a three dimensional object comprising: a
scanning module for measuring three dimensional position information about an
object; a video module for displaying image information obtained from the scanning
module; a processor operating with the scanning and video modules and permitting
the use of the image information displayed by said video module to further refine
the targeting of the scanning module.

Brief Summary Text (36):
The subject invention further includes an apparatus for obtaining positional

information about surface points of a three dimensional object comprising: a scanning module for measuring three dimensional position information about an object, said scanning module including a laser for emitting a beam of visible radiation; and a processor for controlling the scanning module and wherein said laser can be manually positioned so that the visible beam will target the portion of the object to be scanned in response to a control signal from the processor.

Detailed Description Text (4):
FIG. 1 is a block diagram that illustrates the invention in its broadest aspect. Referring to FIG. 1, a Field Digital Vision (FDV) module 10 includes a scanning sensor for scanning an object 20 and for sensing the position in three-dimensional space of selected points on the surface of the object 20. The FDV module 10 generates a point cloud 30 which represents the sensed positions of the selected points. The point cloud 30 also represents other attributes of the sensed positions, such as reflectivity, surface color and texture.

Detailed Description Text (5):
A Computer Graphics Perception (CGP) module 40 interacts with the FDV to provide control and targeting functions for the FDV module 10 sensor. In addition, using the point cloud, the CGP module 40 recognizes geometric shapes represented by groups of points in the point cloud 30, and the CGP module generates a CGP model 42 that represents these geometric shapes. From the CGP model 42, the CGP module 40 generates a further model usable by computer-aided design (CAD) tools 50. The CAD tools may be conventional.

Detailed Description Text (8):
Referring to FIG. 2, the FDV 10 includes a scanning laser system (lidar) 210 that scans points of the object 20 and that generates a lidar data signal that precisely represents the position in three-dimensional space of each scanned point. The lidar data signal for groups of scanned points collectively constitute the point cloud 30. In addition, a video system 220, preferably including both wide angle and narrow angle CCD cameras, is provided. The wide angle CCD camera of the video system 220 acquires a video image of the object 20 and provides, to the CGP 40 via a control/interface module 230 of the FDV 10, a signal that represents the acquired video image.

Detailed Description Text (16):
Each data point in the point cloud 30 generated by the FDV 10 represents both distance to a corresponding laser impingement point from an FDV 10 "origin point" and the angle from the origin point to the laser impingement point. The CGP software conFig.s the CGP 40 computer to process the data points of the point cloud 30, generated by the lidar 210 as a result of scanning the object 20, to display and visualize the scanned portions of the object 20. More specifically, the CGP software conFig.s the CGP 40 computer to recognize geometric shapes in the object 20 ("graphic perception") and, using these recognized geometric shapes, to perform geometry construction, 3D model construction, 3D visualization, and database functions for automated acquisition or manual input of object attributes, generation of plans, sections, and dimensions, data query, and CAD interfaces, and networking options.

Detailed Description Text (125):
Referring to FIG. 15, the CGP 40 is a software system that runs on a CGP Computer 1500 and communicates with the FDV 10. The CGP 40 runs on many different types of computers, including laptops and workstations. The CGP 40 operates on a computer 1500 with a suitable display device 1510, such as a color graphic display terminal, a suitable character input device 1520, such as a keyboard, and a suitable pointing device 1530, such as a mouse. The software can use any number of standard 3-D graphics rendering libraries to interactively present the acquired 3-D data in a window on the display device. The portion of the CGP 40 user interface that involves 3-D view manipulation and data projection into a window is handled by the

3-D library.

Detailed Description Text (126):
The CGP 40 performs real time 3-D data acquisition and modeling in the field. The
CGP's 40 functionality includes high level FDV 10 control, targeting and data
acquisition; display and visualization of scanned points; surface segmentation and
fitting; manual 3-D model construction; 3-D visualization; interaction with part
and model databases; and the ability to export data in standard data exchange
formats to other CAD systems for further processing. The integration of hardware
and software, as described here, enables major improvements in productivity and
quality in the overall process of three dimensional modeling of reality.

Detailed Description Text (127):
With reference to FIG. 1A, the data acquisition and modeling process divides into
the following steps: FDV 10 control, point acquisition, segmentation, geometry
fitting, modeling by manipulating the geometry, scene registration with or without
warping, model annotation, and geometry display and query.

Detailed Description Text (137):
With reference to FIG. 17B, the data returned by the FDV 10 consist of the
coordinates of the points and their intensity values. In one preferred embodiment,
the scanning is performed in such a way that the data returned lies in an ordered
grid of three dimensional points 1730. Viewed from the scanner, these points appear
as a regular rectangular grid, much like a bitmap. However, each point consists of
its coordinates in three-space as well as the intensity of the reflected laser
pulse at that location.

Detailed Description Text (168):
Many common CAD operations such as extension, intersection (mutual extension) and
trimming are available in the CGP 40. For example, the cylinder 3110 in FIG. 31
does not initially extend to the plane of the floor 3120. In FIG. 32 the cylinder
3220 has been extended to the floor plane 3120. These simple operations enable
rapid completion of portions of the model from the objects created by geometry
fitting. For instance, given three planar patches that were fit from scan data near
a corner, it is easy to mutually extend the three planes to complete the corner
feature.

Detailed Description Text (226):
It is possible to automatically partition the scan points into groups representing
primitive geometrical shapes by using variations of common machine vision
techniques. A gridded scan field is stored in a two dimensional array of points,
much like a regular bitmap. The scan field differs from a bitmap in that more
information is stored at each location than just a color. Each point stores its
location in space, from which the distance to the scanner can be calculated, as
well as the intensity of the return laser pulse. The depth information calculated
from the three dimensional position stored at the points is crucial to the
automated segmentation algorithm described here, even though many operations, such
as filtering, rating, thresholding and thinning are commonly used image
manipulation operations.

Detailed Description Text (227):
The first stage of the auto-segmentation process is to estimate the surface normal
at each point in the grid. This can be achieved using many different techniques,
the current embodiment of the software fits a plane to the nearest neighbors of the
point in the 3 by 3 grid surrounding it. The normal of the resulting plane is taken
as the normal at the center point. Each point in the grid has a normal calculated
in the same way, except that edge and corner points ignore the missing neighbors in
the normal calculation. The normal stored at each point is a three dimensional
vector and is normalized to have unit length.

Detailed Description Text (241):
The resulting model can be exported to any of a number of CAD programs for further editing or designing. In the preferred embodiment, the CGP 40 can create a CAD file in a format compatible with several commercial CAD programs, and can then start the CAD program, having it load the generated data file. With both the CGP and the CAD program running, the user can then view and work with the model using either program.

Detailed Description Text (246):
The user interface module will interact closely with the model viewing module which manages display of the object database. The user interface module will not handle display of, picking in, or management of scene graphs. This functionality will be encapsulated in the Model Viewing Module.

Detailed Description Text (249):
The model viewing module encapsulates all functionality involving the display of the object database and display of feedback and auxiliary information in the object scene. Most of the base functionality is provided by Inventor but a strong encapsulation of this module will prevent dependence on Inventor.

Detailed Description Text (253):
The model viewing module is tightly coupled to the Database Module and the geometric objects which it contains. Geometric objects will be stored separately in the database and the scene requiring that care be taken to insure the consistency of the object database with the scene that the user is viewing. This separation allows such operations as viewing subsets of the database, highlighting an object as feedback to a tool, and use of spatial hierarchies within the database to be performed intuitively.

Detailed Description Text (261):
The database module consists of such items as: Addition of geometric objects and images to the database Retrieval of geometric objects and images from the database Disk storage and caching Checking in/out of database objects for editing operations

Detailed Description Text (264):
The I/O module encapsulates the transition of the geometric database from a run-time state to an inoperative state and back. The I/O module also encapsulated the translation of a geometric database to various third party CAD formats (DXF, etc), and the construction of an internal geometric database from such formats.

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Chia-Wei Liao et al., "Surface Approximation of a Cloud of 3D Points", Graphical Models and Image Processing, Jan. 1995, vol. 57, No. 1, pp. 67-74.*

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Shinichi Tamura et al., "Error Correction in Laser Scanner Three-Dimensional Measurement by Two-Axis Model and Coarse-Fine Parameter Search", Pattern Recognition, Mar. 1994, Vo.. 27, No. 3, pp. 331-338.

Other Reference Publication (13):
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D.S. Schwartz, "Vision Metrology System: An Automated Noncontact <u>Three-Dimensional</u> Measurement System," General Dynamics Corporation, Copyright 1989, 7 pages in length, (Month Unknown).

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L4: Entry 155 of 155   File: USPT   Sep 5, 1995

US-PAT-NO: 5448686
DOCUMENT-IDENTIFIER: US 5448686 A

TITLE: Multi-resolution graphic representation employing at least one simplified
model for interactive visualization applications

DATE-ISSUED: September 5, 1995

INVENTOR-INFORMATION:

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APPL-NO: 07/816687   [PALM]
DATE FILED: January 2, 1992

INT-CL-ISSUED: [06] G06T 5/00

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TYPE	IPC	DATE
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US-CL-ISSUED: 395/120; 395/123, 395/128
US-CL-CURRENT: 345/420; 345/423, 345/428

FIELD-OF-CLASSIFICATION-SEARCH: 395/119-121, 395/123-132, 395/133, 395/135, 358/456

See application file for complete search history.

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

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Computer Vision Graphics and Image Processing, vol. 51, NO. 3, Sep. 1990, USA pp. 338-354 XP172437 Manohar et al.

ART-UNIT: 242

PRIMARY-EXAMINER: Jankus; Almis R.

ATTY-AGENT-FIRM: Perman & Green

ABSTRACT:

A method for execution by a data processor that prepares an object for display. The method includes a step of processing a first model of the object so as to produce a simplified model thereof, the step of processing including the steps of (a) superimposing a first plurality of grid cells on the first model; for any one of the first plurality of grid cells containing more than one vertex of the first model, (b) combining the vertices into a first representative vertex; (c) generating a first simplified model that includes the first representative vertex or first representative vertices; and (d) storing the first simplified model for subsequent use. The method encompasses a number of criteria for use by the step of combining the vertices within a grid cell. These criteria include: (a) selecting a center of the grid cell as a position of the representative vertex; (b) selecting a position of a predetermined one of the vertices within the grid cell as a position of the representative vertex; (c) selecting an average position of the vertices as a position of the representative vertex; (d) selecting a position of a vertex that is nearest to the average position as a position of the representative vertex; and

(e) selecting a position of a vertex that represents a locally extreme point within the grid cell as a position of the representative vertex.

28 Claims, 26 Drawing figures

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L4: Entry 155 of 155   File: USPT   Sep 5, 1995

DOCUMENT-IDENTIFIER: US 5448686 A
TITLE: Multi-resolution graphic representation employing at least one simplified
model for interactive visualization applications

Brief Summary Text (4):
Graphic representations of large size engineering models, medical images, or
computer generated scenes for multimedia applications typically contain millions of
facets, that is, elements of surface tesselations. The computing power required for
rendering such complex models, in realtime, is presently beyond the reach of
parallel data processing architectures. However, realtime interactive manipulation
of viewing conditions provide important clues for understanding an object's
geometry and relative positions. In general, these visual clues cannot be obtained
from sequences of static images. Furthermore, interactive viewpoint manipulation to
accomplish, by example, a walkthrough through an engineering assembly model, or to
visually inspect medical data, requires realtime feedback and smooth object motion.

Brief Summary Text (5):
To achieve the required performance, it is known to use an alternate representation
of the model, which is less computationally expensive to display. For example, in
many Computer Assisted Design (CAD) and animation systems wireframe models, or
boxes placed around the objects, are used during realtime manipulation. However,
these simplified graphic substitute models often produce images having thousands of
displayed lines. This number of lines is difficult to interpret, especially in
clustered visual environments.

Detailed Description Text (16):
The second approach has the advantage of operating on simpler models, and thus is
in general faster. Simplification factors refer to an absolute size of three-
dimensional areas used for clustering.

Detailed Description Text (20):
Clustering is a process by which the vertices are grouped. Grouping is preferably
accomplished based on geometric proximity. A simplest grouping test is to partition
a box that encloses an object into a set of disjoint three-dimensional cells, and
to declare that all vertices that fall within a single cell are a cluster.
Regularly spaced cells are relatively simple to implement, in that given the
coordinates of a vertex, the cell to which the vertex belongs is obtained by
rounding off the vertex coordinates. One suitable formula for this round-off
operation is as follows: Let I,J,K represent the cell address in three dimensions.
Let X0 and X1 represent the lower and higher X coordinates of the bounding box.
Similar notation is used for the Y and Z coordinates. X,Y, and Z represent the
vertex coordinates, K is the simplification factor, and DX, DY, DZ are the
dimensions of a cell:

Detailed Description Text (43):
FIG. 5a illustrates an object Model 34 having a three dimensional grid 36a
positioned thereon. The grid 36a has a first resolution that results in only one

vertex appearing in any given grid cell. As a result, by whatever clustering method is employed, the resulting object Model 34a (FIG. 5b) duplicates the original Model 34.

Detailed Description Text (44):
FIG. 6a illustrates the object Model 34 having a second three dimensional grid 36b positioned thereon, the grid 36b having a resolution that is one half that of the grid 36a. As a result, in the grid cells designated with asterisks (*) more than one vertex is found. For these grid cells the application of one of the clustering methods described above, such as averaging, results in the simplified Model 34b of FIG. 6b. It should be noted that a portion of the simplified Model 34b is reduced to an edge, as seen in the lower portion of the simplified Model 34b. When such an edge survives the simplification process, it is kept and displayed as a line segment. An example of the importance of maintaining edges is illustrated in FIGS. 13a and 13b, wherein FIG. 13a illustrates an original Model, with triangulation, and FIG. 13b illustrates the simplified Model which is composed of two edges. In that the adjacent vertices of the original Model all lie within common grid cells, if the resulting edges were not preserved the simplification technique would result in the elimination of the simplified Model.

Detailed Description Text (45):
FIG. 7a illustrates the object Model 34 having a third three dimensional grid 36c positioned thereon, the grid 36c having a resolution that is one half that of the grid 36b. As a result, in the grid cells designated with asterisks (*) more than one vertex is found. For these grid cells the application of one of the clustering methods described above, such as averaging, results in the simplified Model 34c of FIG. 7b.

Detailed Description Text (54):
So as to simplify this analysis, it is assumed that the object Model has been previously simplified to level 1 by using a resolution R that defines N cells, and that the Model involved V supporting points (vertices of the polyhedra). A description is now provided of a technique to estimate the number of points resulting from a simplification at level 2 with resolution 2R. For simplicity, the same resolution factor in all three dimensions is employed, although in practice a different resolution factor may be used for each dimension.

Detailed Description Text (60):
As an alternative to the above approach, where the same simplification level is used for all of the displayed models, an adaptive approach may be employed. For this approach the system 10 selects an appropriate simplification level independently for each object. This selection may be performed, using the enclosing box around each object, by determining the size of the projection of the bounding box on the screen plane (as in FIG. 10), and by comparing the size of the projection to predetermined limit values. To this end, a further storage device 12b is provided wherein there are stored screen projection limit values for each Model (LIMITS M.sub.1 --LIMITS M.sub.i). CPU 12 accesses these limits and compares same to the determined screen projection size for a particular Model. Based on this comparison, an appropriate Model is selected from the memory 12a. Objects that project onto small figures on the screen plane are rendered using a strongly simplified Model. The limit values may be different for each Model, or may be tabulated depending on the Model complexity. For example, if a Model has a small number of faces, there is no significant advantage in using a simplified Model, even when the Model's projection on the screen is small. During this projection process, Models that do not project on the screen, or that project onto some predetermined lower threshold limit of display pixels, are detected and not displayed. The enclosing three-dimensional boxes are computed in the local coordinate systems of the Model, and may be propagated in the Model's hierarchy to permit the elimination of entire sub-assemblies.

Detailed Description Text (64):
FIG. 11 is a flowchart that depicts the operation of the method of the invention.
At Block A the system 10 loads or generates a <u>database of objects</u> appearing in a
scene to be displayed. By example, the objects may be elements of a <u>CAD</u> database of
mechanical parts and assemblies of parts. These objects are triangulated using one
of a number of known types of triangulation methods. As a result, the surface of
each object is tesselated as in FIG. 2. Then, for each object, and for each
simplified Model of the object, the system performs the following steps. At Block
C, the vertices are grouped by clustering in accordance with the resolution of a
selected sampling grid. At Block D, the Model is simplified by detecting and
removing degenerate and duplicate triangles. At Block E the simplified Model is
stored in the memory 12a in association with its base Model. At the completion of
Block E for all of the simplified models, and for all of the objects, the system 10
is ready to begin an interactive display session with a user.

Detailed Description Text (101):
(B) Construct a <u>three-dimensional</u> minimax box around the entire object and divide
the <u>three-dimensional</u> minimax box uniformly into K.times.L.times.M approximately
square cells. For each object, and for each internal node, store a string of
K.times.L.times.M bits.

Detailed Description Text (105):
Also, although the object has been described in the context of two dimensional and
<u>three dimensional</u> grid cells having substantially uniform linear dimensions, it
should be realized that the grid cells may have a variety of shapes. FIG. 9
illustrates one embodiment wherein an object Model 46 has a <u>three dimensional</u>
circular grid 48 superimposed thereon. The grid 48 is characterized by a set of
segmented concentric circles, the grid cells providing increasing resolution
towards the center of the grid. The clustering techniques described in FIGS. 4a-4e
are also applicable to the grid cell geometry shown in FIG. 9.

CLAIMS:

21. A method as set forth in claim 14 wherein the plurality of the <u>three</u>
<u>dimensional</u> grid cells are of different sizes.

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